Localized Precipitation and Temperature Response to Drought in Urban and Natural Areas

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Key Findings

- Tucson and the Santa Rita Experimental Range (SRER) respond differently to drought.
- The SRER generally follows regional trends for precipitation response to drought, whereas Tucson has a less extreme response.

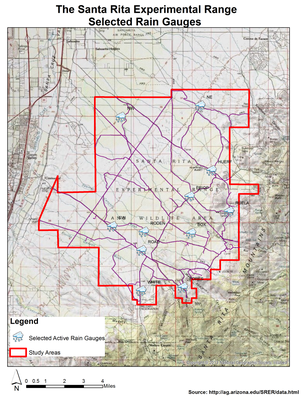
1. Introduction

This study examines the different responses of urban and natural areas to a regional meteorological drought. We compare the precipitation and temperature responses to regional drought in the SRER and in Tucson, and we also compare the Palmer Drought Severity Indices (PDSI) for these areas. We hypothesize that the regional drought will have a less pronounced relationship with the SRER than Tucson because of the difference in urbanization between the two areas.

2. Methods

Study Site: Arizona Climate Division 7, the SRER, and the City of Tucson

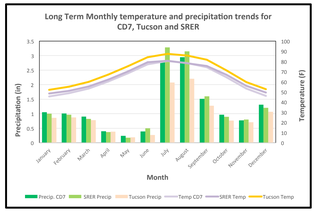
- Arizona Climate Division 7 (CD7) encompasses the southeastern part of the state.
- The SRER is located 40 km south of Tucson and contains undeveloped desert grassland vegetation.
- The City of Tucson is the 33rd largest city in the United States with a population of more than 524,000.



Data Collection

- SRER precipitation data were taken from the SRER Long-term Transect and Spatial Data for the years 1923 to 2012. Measurements from 11 rain gauges were arithmetically averaged to produce monthly precipitation totals for the SRER.
- Precipitation, temperature, and PDSI data for CD7 and Tucson and temperature and PDSI data for the SRER were taken from the West Wide Drought Tracker for the years 1923 to 2012.

3. Results



Precipitation and Temperature Trends in CD7, the SRER, and Tucson

- Between 1923 and 2012, the long-term average temperature in Tucson is 69.3°F, compared to 64.4°F for the SRER and 62.5°F for CD7.

Comparison of PDSI, Precipitation, and Temperature for Selected Years

PALMER DROUGHT SEVERITY INDEX	CD7				SRER				TUCSON			
	Actual	Expected	Difference	Drought Classification	Actual	Expected	Difference	Drought Classification	Actual	Expected	Difference	Drought Classification
1930-1933	1.45	-1.72	3.17	slightly wet	2.43	-0.34	2.77	moderately wet	1.07	-0.08	1.16	slightly wet
1943-1957	-1.49	-1.72	0.23	mild drought	-1.40	-0.34	-1.06	mild drought	-1.43	-0.08	-1.35	mild drought
1982-1995	2.04	-1.72	3.76	moderately wet	2.47	-0.34	2.81	moderately wet	1.58	-0.08	1.66	slightly wet
2002-2012	-1.99	-1.72	-0.27	mild drought	-3.46	-0.34	-3.12	severe drought	-1.69	-0.08	-1.60	mild drought

PRECIPITATION	CD7				SRER				TUCSON			
	Actual (in)	Expected	Difference	% Change	Actual (in)	Expected	Difference	% Change	Actual (in)	Expected	Difference	% Change
1930-1933	16.08	14.28	1.80	113%	17.44	14.71	2.73	119%	12.45	11.43	1.02	109%
1943-1957	12.36	14.28	-1.93	87%	12.86	14.71	-1.86	87%	9.88	11.43	-1.56	86%
1982-1995	17.11	14.28	2.83	120%	17.55	14.71	2.84	119%	13.50	11.43	2.07	118%
2002-2012	12.51	14.28	-1.77	88%	12.86	14.71	-1.86	87%	10.38	11.43	-1.05	91%

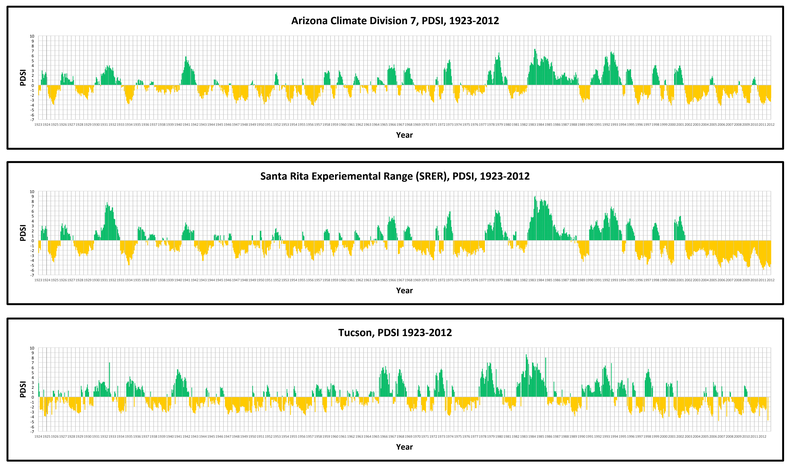
TEMPERATURE	CD7			SRER			TUCSON		
	Actual (F)	Expected	Difference	Actual (F)	Expected	Difference	Actual (F)	Expected	Difference
1930-1933	61.99	62.52	-0.53	63.84	64.40	-0.56	68.06	69.32	-1.27
1943-1957	62.29	62.52	-0.23	63.99	64.40	-0.41	68.75	69.32	-0.57
1982-1995	62.48	62.52	-0.05	64.31	64.40	-0.09	69.72	69.32	0.39
2002-2012	63.77	62.52	1.24	65.89	64.40	1.49	71.12	69.32	1.80

denotes wet years, regionally
denotes drought years, regionally

Actual the monthly average for the selected years
Expected the long-term monthly average for 1923-2012

- From 1923 to 2012, the SRER received more rain than Tucson but had a higher overall PDSI.

Comparison of long-term meteorological drought trends



- In the most recent drought period, the PDSI for the SRER deviates from the expected value by 3.12, where as the deviation for Tucson is only 1.6. The ongoing drought in the SRER is classified as severe, compared to a mild drought in Tucson and regionally.
- In the selected wet years, the PDSI for the SRER increased by approximately 2.8, compared to an increase for Tucson of 1.4.

Comparison of long-term precipitation trends to regional drought

- From 1923 to 2012, the long-term average rainfall in the SRER was 14.71 in compared to 11.43 in for Tucson and 14.28 in for CD7.
- During the selected periods, the SRER precipitation response to drought generally followed regional trends, whereas the precipitation response in Tucson was lower than both precipitation in the SRER and in CD7.

4. Discussion & Conclusions

Overall Tucson receives less precipitation and is hotter than the SRER and the region but does not show a more pronounced precipitation or temperature response to regional drought. In general, the SRER has more significant changes in precipitation and PDSI. This unexpected result may be caused by differences in elevation, urban irrigation, or other factors, which are important to consider as population growth in southern Arizona expands into natural areas.

5. Future Investigation

- Map the vegetative cover in the SRER and Tucson to determine vegetative response to drought.
- Examine urban irrigation trends to help explain why the PDSI for Tucson is less than for the SRER.
- Investigate the urban impacts on rural areas, such as groundwater or surface water extraction, to help explain differences in drought response between the SRER and Tucson.

Acknowledgements
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References
West Wide Drought Tracker, http://www.wrcc.dri.edu/wwdt/index.php (last visited October 9, 2013)
Santa Rita Experimental Range Long-Term Transect and Spatial Data, http://ag.arizona.edu/SRER/data.html (last visited October 9, 20130)